ABSTRACT
        Three aspects of concept teaching might be guided by
the conceptual learning and development model. First, by assessing
the characteristics of cognitive style, classificatory skills, and
logical reasoning ability, the student's readiness to attain concepts
under various circumstances can be determined. Secondly, the model
points to optimal methods for teaching concepts. The basic strategy
in determining such methods is to note the cognitive operations
entailed in reaching the desired level of concept attainment, then to
speculate on conditions which would either hinder or facilitate these
operations. Instructional methods which are effective in concept
instruction may be related to the operations postulated by the model.
In turn, new instructional methods might be formulated on the basis
of their potential for facilitating one or more cf these operations.
Thirdly, the model provides direction in the search to find ways of
adapting concept instruction to individual needs of the learner.
(RC)

Implications of the Model for Instructional Design[1,2]

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The earlier presentations in this symposium have outlined a model of conceptual learning and development and presented empirical evidence related to the model. As you have listened to these presentations, perhaps you have thought of research studies which might be carried out to test the validity of the model or have considered its implications for your own area of interest. My experience with the model has been that it serves as an excellent framework for understanding the results of previous research on concept learning and leads to the prediction of internal and external conditions which may affect learning.

I would like to share with you today what I see as the implications of the model for instructional research and design. It seems to me that there are three aspects of concept teaching which might be guided by the model: (1) assessing the readiness of the learner to attain specified types of concepts under various instructional conditions, (2) establishing optimal conditions for concept mastery, and (3) adapting instruction to the needs of the learner.

First, let us consider the implications of the model for assessing readiness. The model specifies cognitive operations involved in reaching four different levels of concept attainment. The ease with which these operations are carried out by a particular learner varies as a function of individual characteristics such as cognitive style, classificatory skills, and logical reasoning ability. By assessing these characteristics, we can determine the student's readiness to attain concepts under various circumstances.

To illustrate the strategy of assessing readiness by testing the student's ability to carry out the necessary cognitive operations, consider the case of the student faced with the task of attaining the formal level of a concept by the discovery method   He is presented with positive and negative examples of the concept and is a ked to infer its defining attributes. The model suggests that under these cond tions, the student must generate hypotheses concerning the

defining attributes, remember the hypotheses, and evaluate them by determining their compatibility with the examples and nonexamples presented. Costello and Dunham (1971) found induction ability to be highly related to the cognitive operations of hypothesis generation, memory, and evaluation. Thus, it seems likely that an induction test might serve as a measure of a student's readiness to learn concepts at the formal level by the discovery method.

As a second example of assessing readiness for concept attainment using the model consider the case of a student learning a concept at the classificatory level. To attain a concept at this level, the learner must generalize that concept instances are alike in some way and must group the instances together because of that likeness. Kofsky (1966) has called this kind of grouping "exhaustive sorting." In her study, she found that only 43 percent of the four-year-old children she tested could sort exhaustively, while 90 percent of the nine-year-old children could sort in this manner. Thus, it appears that many children of primary age may have difficulty in attaining concepts at the classificatory level because of a deficit in classificatory skills. Perhaps tests of these skills would aid in determining readiness for learning concepts at the classificatory level.

As a final example of readiness tests derived from the model, think of a child who is learning a concept by examining actual examples of the concept or pictorial representations of those examples. Some degree of discrimination of attributes is required at all levels of concept attainment, with the sharpest discrimination required at the formal level. A child who has difficulty analyzing a stimulus configuration will undoubtedly have difficulty in learning concepts from real or pictorial examples. Several studies have confirmed this relationship between analytic ability and concept learning (Davis, 1967; Elkind, Koegler, & Go, 1963; Fredrick, 1968). The inference is that a test of analytic cognitive style might serve as a readiness test for concept learning from perceptible instances.

Two points should be noted in considering the implications of the model for developing readiness tests for concept attainment. First, the question is not whether the child is ready for all types of concept learning, but whether he is ready to learn a particular kind of concept, whether he can learn it at a given level, or whether he can learn it under specified instructional conditions. Reflecting back on the examples we have given, a child with a global style may have difficulty in learning perceptual concepts but not in learning verbal concepts. A child with poor inductive reasoning ability may be able to learn a concept at the classificatory level but have difficulty attaining the formal level under the discovery method of instruction. If an expository method were used, he might be able to move up to the formal level. As the model makes clear, the cognitive operations which take place depend on the nature of the concept, the level to be attained, and the kind of instruction. In turn, the abilities necessary for learning a concept also depend on these variables.

The other point to be considered in thinking of readiness tests is that many of the abilities related to the cognitive operations show developmental trends. For example, Kofsky (1966) has shown increases in classificatory sorting ability with age, and Fredrick (1968) has shown increases in degree of analytic style. The longitudinal study currently being carried out by the Wisconsin Center should provide important information concerning the emergence of cognitive abilities and shed light on the contingencies between these abilities and concept attainment. Where contingencies are established, the predictive value of a cognitive ability test is confirmed. A teacher might take one of two courses of action in the case of a child shown to be deficient in an important cognitive ability. If the ability was easily modifiable, he might train the child in the ability prior to concept instruction. If the ability was not easily modifiable, he might delay concept instruction until the child's ability had naturally developed to a higher degree.

As we have shown, the model suggests ways to assess readiness for concept learning. It also points to optimal methods for teaching concepts. The basic strategy in determining such methods is to note the cognitive operations entailed in reaching the desired level of concept attainment, then to think of conditions which would either facilitate or hinder these operations. Research is then carried out to determine whether these conditions do, in fact, have a differential effect on concept mastery. An example of this strategy is as follows. We note that discrimination of attributes is an operation which is necessary at all levels of concept mastery. In turn, we hypothesize that giving information to the learner about the attributes of concept instances will facilitate this discrimination and therefore concept learning itself. This hypothesis has been supported by studies showing that instructions which point out attributes facilitate concept mastery (Klausmeier & Meinke, 1968; Pishkin, 1965).

In similar fashion, most of the variables which optimize concept learning appear to relate to one or more of the cognitive operations postulated by the model. To show the possible relationships between the model and effective instructional methods, I will take each of the operations and briefly outline the variables which might be inferred to have their effect on concept learning through facilitation of that operation.

First, consider the operations of attending and discriminating. As noted above, giving instructions about attributes of concept instances increases rate of mastery. Techniques such as increasing the difference among values of an attribute or using emphasizers also promote attention and discrimination (Archer, 1962; Trabasso, 1963). In cases where stimuli are complex and attributes are unfamiliar to the student, pretraining in labeling the attributes may facilitate

attribute discrimination and, therefore, concept learning itself (Deno, Jenkins, & Marsey, 1971).

As you can see, then, acceptance of attending and discriminating as fundamental operations entailed in concept mastery leads to the hypothesis that concept learning will be improved by any instructional method which helps the learner to attend to attributes and discriminate them from one another. At least three such methods have already been demonstrated to be effective: (a) pointing out the attributes of concept instances, (b) increasing the salience of attributes by manipulating the difference among attribute values or using emphasizers, and (c) teaching the student to label attribute values. Perhaps other methods could also be devised to facilitate these operations.

Another operation in the model which we might examine as a source of ideas for effective instructional methods is that of remembering stimulus information. The most obvious way of reducing the need for remembering is by presenting all concept instances at the same time. This method has, in fact, been shown to have a marked facilitative effect on concept mastery (Clark, 1971).

Klausmeier, Ghatala, and Frayer (in press) have suggested that there are other, more subtle determinants of memory load. These determinants also suggest ways of optimizing concept learning in particular situations. For example, if instances must be presented successively instead of simultaneously, we hypothesize that performance would be better if each successive instance varied from the previous instance in only one way. If this is done, the learner can draw an inference about the relevance of an attribute from those two instances only, and need not keep in mind information from many instances. Thus, we may be able to reduce memory load in ways other than simply presenting instances simultaneously.

An operation postulated by the model which is of particular relevance to educators is generalizing different instances as equivalent, the key operation

at the classificatory level. Markle and Tiemann (1969), Merrill and Tennyson
(1971), as well as researchers at the Wisconsin Center (cf., Feldman, 1972;
Swanson, 1972) have done extensive theorizing and research related to optimal
ways of facilitating this operation. Basically, the analysis is that we want to
lead the student to generalize to all examples of the concept, but to discriminate
these examples from nonexamples. There are two very important instructional
techniques which facilitate appropriate generalization: (a) presentation of a
wide variety of positive examples, and (b) presentation of nonexamples which
might be easily confused with examples (Markle & Tiemann, 1969).

The final set of operations to be considered in deriving instructional
implications is that of inferring the concept by testing hypotheses. This set
of operations is actually comprised of three interrelated operations--- formula-
ting, remembering, and evaluating hypotheses. Instruction which facilitates
any one of these operations would increase the probability of concept attain-
ment at the formal level.

One important aspect of instruction related to this set of operations is
that the student should be aware of the objective. That is, the student should
be told that he is to look for the features which are common to all concept
instances. This type of direction leads the student to engage in the desired
hypothesizing behavior. Studies comparing intentional and incidental concept
learning have demonstrated that such directions are effective (Amster, 1965;
Shaffer, 1961).

The probability that a student will choose the correct hypothesis is de-
pendent on, among other factors, the total number of hypotheses. The total number
of hypotheses is, in turn, dependent on the amount of irrelevant information.
Irrelevant information may be reduced by using a simplified drawing or verbal
description of an instance in place of a real instance. The massive amount of
research evidence supporting the facilitative effect of decreasing irrelevant
information (Clark, 1971) suggests that this is a very important instructional
variable.

The evaluation of hypotheses is a relatively sophisticated information processing task. One might hypothesize that instruction in carrying out this task would facilitate concept attainment at the formal level. Such instruction would consist of providing inferential rules for drawing conclusions about the information in concept instances. Two studies have shown that this kind of instruction can, in fact, improve concept learning performance (Archer, Bourne, & Brown, 1955; Klausmeier & Meinke, 1968).

The examples which I have given are but a few of the instructional methods suggested by a consideration of the cognitive operations postulated by the model. Most of the instructional methods I have reviewed are already supported to some degree by previous research on concept learning. In fact, some of the research has been used to derive or provide evidence for the model. To the extent that this is true, the listener might argue that the reasoning presented is circular. That is, if we say that a particular cognitive operation is entailed in concept learning based on the effect of a particular instructional manipulation, we cannot say that the manipulation is effective because the cognitive operation is involved. With no additional information, the most we could say is that the model provided us with a useful way of organizing and thinking about previous research on concept learning.

The validity of the model, however, can be directly tested by new research studies designed to determine whether the cognitive operations postulated are actually called into play during the concept learning process. Such research has already been mapped out (Klausmeier, Ghatala, & Frayer, in press). Furthermore, the instructional implications of the model are not limited to those conditions which have already been shown to be effective. Knowing that discriminating attributes is important to concept learning, the researcher might devise a new instructional approach intended to facilitate attribute discrimination and then test its effect on concept learning. We look forward to the testing of the

model and to the formulation of predictions based on it. As this is accom-
plished, the model will begin to serve the generative function in improving
instruction that we intend.

Up to this point, I have attempted to show how the model might be used
as a basis for developing readiness tests or new instructional methods. There
is an additional use for the model which I would like to describe briefly, and
that is as a basis for adapting instruction to the needs of the learner. The
thinking behind this strategy is as follows: (a) Certain individual differences
have been identified in the learner's ability to carry out various cognitive
operations. (b) Certain instructional methods have been found to facilitate these
cognitive operations. (c) For learners who have difficulty carrying out a par-
ticular cognitive operation, an instructional method which facilitates the opera-
tion might assist them in learning, This approach is essentially that of the
compensatory model of the aptitude by treatment interaction outlined by Salomon
(1972).

The Concept Learning and Development (CLD) model provides a basis for such
intervention by describing the operations entailed in concept learning. At this
point in time only two studies have been carried out to test the effects of such
intervention (Nelson, 1972). In the first study, subjects were classified as
having an analytic or non-analytic cognitive style and studied lessons which
either emphasized the attributes of concepts or did not emphasize them. The
hypothesis was that analytic subjects would learn equally well from either type
of lesson, while non-analytic subjects would learn better from the lesson which
emphasized attributes. The thought was that non-analytic subjects would have
difficulty in discriminating attributes. By emphasizing or calling attention to
the attributes, this difficulty would be obviated. In the second study, the
relative level of attainment of reflective and impulsive students who had studied

discovery or expository lessons was observed. The hypothesis was that reflective students would do equally well whether they studied discovery or expository lessons, while impulsive students would do better when they studied expository lessons. The reasoning behind the hypothesis was that reflective students would carefully test their conjectures about the concept when studying the discovery lesson, while impulsive students would leap to incorrect conclusions.

In neither of the two studies, however, was the predicted interaction obtained. Thus, while it is clear that the CLD model offers a fertile source of hypotheses concerning aptitude by treatment interactions in concept learning, it is too soon to judge whether any of these interactions will be of sufficient magnitude to be of practical instructional use.

In summary, the CLD model has many implications for instructional design. The ability to perform the cognitive operations postulated at each level might be assessed in order to determine a child's readiness to learn concepts at that level under specified instructional conditions. Instructional methods which are effective in concept instruction may be related to the operations postulated by the model. In turn, new instructional methods might be formulated on the basis of their potential for facilitating one or more of these operations. Finally, the model provides direction in the search to find ways of adapting concept instruction to individual needs.

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